URBAN SCIENCE.
ENGAGING SCIENCE,
CREATING SUSTAINABLE CITIES

LEARNING MODULES

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SOUNDS IN THE CITY

Learning module
from the series SDG challenges in my city

Developed in the project
Urban Science
Engaging science, creating sustainable cities
co-funded by the Erasmus+ Programme of the European Union.

This module was created and first piloted by teacher members of the Hungarian Research Teachers' Association.

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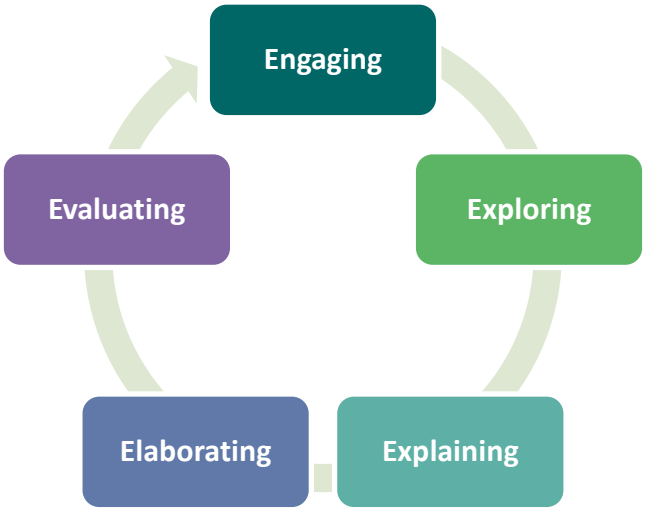
LEARNING MODULE

SOUNDS IN THE CITY

"This module calls for many alternative opportunities and I enjoyed experimenting with them in different group. Mapping as a tool provides an interesting context, although some student teams may need stronger support to complete a quality science project."

(Mónika, science teacher from Hungary)

Activities in this module are organised around the 5E instructional model of inquiry-based learning.



Challenges linked to Sustainable Development Goals

- Strong links to SDG **3**: Ensure healthy lives and promote well-being for all at all ages, SDG **9**: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation, SDG **11**: Make cities and human settlements inclusive, safe, resilient and sustainable and SDG **12**: Ensure responsible consumption and production patterns
- Links to SDG **15**: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

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This module can be used individually or within the Storyline introduced by the module Back to the Future: Climate Change.

The scores for gamification are suggestions that teachers may modify according to their preferred pedagogical scenarios.

Introduction

The starting point of this module is that sounds (voices, sputters, noises, burrs) that surround us in a city might be disturbing or distracting, yet if we pay attention, they can be exciting and interesting, so it is worth examining them.

While students are mapping sounds, they learn about the scientific background of sounds and get acquainted with some data about how sounds affect animals and people. Finally, they get a taste of an artistic way of working with sounds.

Alternatively, with web resources for the jigsaw, this module can be turned into a mixed environment webquest too.

Learning objectives

- raising students' attention to the relevance of sounds in the city they live or study
- raising students' awareness to the fact that sounds in the city have different effects and consequences to the different species and to the different groups in the city's human population
- raising students' awareness to the fact that city planning means seeking consensus or making compromises and involves complex thinking considering very different points of views and a diversity of needs
- seeking solutions to cope with noise pollutions
- seeking solutions to eliminate or minimise noise pollution
- developing science competences: data collection, data processing, comparing data, causality
- developing cognitive skills in social inquiry competences: problem-solving, critical thinking, creativity
- developing communication inquiry competences: forming evidence-based statements and expressing opinions, communicating results
- developing civic competence elements in sustainability competences: responsibility, civic participation, transdisciplinarity, agency
- using digital competences (in collecting and working with noises)
- using foreign language competences (in data-collection: possibility)

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Learning outcomes

- students recognise the relevance of sounds in their daily life
- students express their agency in seeking solutions to cope with noise pollution in their city
- students gain knowledge about sounds (Physics: waves)
- students gain knowledge about hearing (Biology: ear' anatomy and physiology, brain)
- students gain knowledge about population and behaviour changes linked to noise pollution (Biology: evolution, ecology)
- students gain information about noise protection
- students practice using maps
- students practice working with scientific data
- students develop empathy towards others
- students develop agency in acting for sustainability

students develop responsibility towards noise pollution

Time needed to implement the Learning Module

180 minutes (4x45 minutes)

Activities in detail

(according to the 5E model)

Engaging

Introduction:

We are still in city S. (Any city name can be used, optionally also the real name of the city where the school is located.) *If your teams work well during this module, your city can take more steps towards being sustainable. If your teams fail; everything will stay as it was in the beginning of this module.*

(Teams can be the same throughout the whole Urban Science learning journey: in this case, individual points in this game's parts add to those team points.)

Story:

Today we take a look at the city, how it was in the 2020s, once we are stuck here. Your teams are challenged to map noises around the school. Take care: some may sound really strange for our 2130 ears. I must remind you of the fact that cyborgs were extremely rare in the 2020s, so we will all use the so-called smartphones of students at that time.

Students work in small groups. They are challenged to take a 15-minute walk on a route previously discussed) and record noises. This can also be a pre-lesson task, or students make recordings on their way to school and back, etc. – 15 minutes
Students listen to recordings and find the exact spot of some noises on a map. Also, they add emoticons (happy and sad faces) to indicate different noises on their maps. – 20 minutes

Exploring

Story:
Now, what questions do you think 2020s students would have based on what you heard?
Students share their noise maps in the class and they formulate questions about the maps (e.g. they jot them on a piece of paper). They make a list of questions and then categorise them (e.g. using bluetack and wall/ board) based on being "science" or "sustainability" or other questions. They plot a Venn-diagram. – 10 minutes

Explaining

Story:
We have some nice questions. Let's discover how pre-2030 science explained noises. You will work with some texts from pre-2030 science textbooks: the things they used for supporting students' learning.
Students work in a jigsaw classroom (e.g. https://www.jigsaw.org/) and get information about how to describe noises scientifically and what can make a noise distracting or delightful to people. They find definitions such as frequency, amplitude, threshold limit, extreme, and the mechanism of hearing and sound processing in the human brain. Students form jigsaw groups so that team members get to different jigsaw groups. – 45 minutes

Elaborating

Story:
Now let me show you some research findings from that time.
Students are introduced data about behavioural changes in singing birds in cities (e.g. blackbirds singing pattern – they sing at night, frequency changes in collared flycatchers in cities, etc.), Students reflect on findings in their original teams (with one member from each jigsaw group. – 10 minutes.
Examples:
science paper: https://www.sciencedirect.com/science/article/pii/S0960982206023086
popular science from Nature: https://www.nature.com/scitable/blog/accumulating-glitches/some_city_birds_are_changing/
science blog: https://ecologicablog.wordpress.com/2015/02/19/urbanisation-is-changing-the-way-birds-sing/

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Students search for data and news concerning people and noise in cities and share it in think-pair-share within their teams. – 10 minutes

Story:

Let's give some advice on what could be done to reduce noise. Beware, they don't know all the technology we have in 2130.

Students in teams discover solutions for noise protection. For example: protective walls, changing road surfaces, planting trees or shrubs, roundabouts instead of traffic lights, rationalising traffic, etc. They design noise protection in parts of their cities in small groups. They present their findings on a map for the group. – 40 minutes

Example from Malmö (in English and in Swedish): https://soundear.com/2016/09/20/reduce-noise-levels-in-cities/

Brief examples: https://newcities.org/blog-combating-urban-noise-echikson/
https://www.planetizen.com/blogs/96881-why-we-need-reduce-noise-levels-cities

Example for data from science paper:
https://www.sciencedirect.com/science/article/abs/pii/S0003682X17300270

Evaluating

How do you think they perceived noise around them?

Students listen to artistic ways of processing noises (e.g. John Cage: 4'33"). After a brief reflection, groups are challenged to make an artistic statement from the noises they recorded. – 20 minutes

Finally, students reflect on practical notions, scientific approaches and artistic expressions of noises. – 10 minutes

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Alternatives to the module

Version 1

Sounds in the city – starting from the school

Engaging

The teacher shows sound recording from the school. Students listen and make guesses on the time when the recording was made and the exact spot, and then they try to identify as many noises as they can. – 5 minutes

They discuss about noises in the school in small groups and then report back to the class in one sentence each. – 10 minutes

Exploring

Students work in small groups. They are challenged to take a 15-minute walk around the school and record noises. While doing so, using apps, they indicate the exact spot of some noises and they create happy/sad noise maps. – 15 minutes
Students share their noise maps in the class and they formulate questions about the maps (e.g. they jot them on a piece of paper). They make a list of questions and then categorise them (e.g. using bluetack and wall/ board) based on being "science" or "sustainability" or other questions. They plot a Venn-diagram. – 10 minutes

Explaining

Students work in teams to find answers to the different clusters of questions using digital textbooks. (This part can also be a home preparation / homework part.) – 30 minutes
Teams report back to the whole class. (Alternatively, they make info boards / project walls / wiki entries in the previous step – especially if that is a home preparation phase – and then share and discuss these in class.) – 20 minutes

Elaborating

Students are introduced data about behavioural changes in singing birds in cities (e.g. blackbirds singing pattern – they sing at night, frequency changes in collared flycatchers in cities, etc.), Students reflect on findings. – 10 minutes.
Some resources:
https://www.countryfile.com/wildlife/loud-aeroplane-noise-found-to-cause-aggression-in-birds/
https://www.nature.com/scitable/blog/accumulating-glitches/some_city_birds_are_changing/
https://ecologicablog.wordpress.com/2015/02/19/urbanisation-is-changing-the-way-birds-sing/

https://www.sciencedirect.com/science/article/pii/S0960982206023086

Students search for data and news concerning people and noise in cities and share it in think-pair-share. – 10 minutes

Then they discover solutions for noise protection. For example: protective walls, changing road surfaces, planting trees or shrubs, roundabouts instead of traffic lights, rationalising traffic, etc.

They design noise protection in parts of their city in small groups. They present their findings on a map for the group. – 40 minutes

Evaluating

Students listen to artistic ways of processing noises (e.g. John Cage: 4'33"). After a brief reflection, groups are challenged to make an artistic statement from the noises they recorded. – 20 minutes

Finally, students reflect on practical notions, scientific approaches and artistic expressions of noises. – 10 minutes

Version 2

Sounds in the city: animals fight back

Role game version 1

Engaging

Students get empty role cards with names of different animal species of them: these might include popular city pets (cat, dog), other urban species (blackbird, cricket): there should be as many types of species as many groups they are expected to form in the Exploring phase later. Groups of 4 or 5 seem to work well. The teacher introduces the story: these animals live in a city. The teacher sketches the city based on the real city they live in. The teacher places a big map of the city in the classroom. One day, they decide to seek for same-species allies to discover if other feel the same way they do about noises in their city. Students are challenged to prepare their role cards. – 10 minutes

Students discuss in groups (cats, dogs, blackbirds, crickets, etc): they introduce themselves. The groups form their hypothesis about how they relate to noises in their city. They plan a route to take to collect evidences. – 15 minutes

Exploring

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The story goes on. Animals go out to check how their peers perceive noises in their favourite and most hated places. Students work in the same groups. They are challenged to take a 15-minute walk on a route (previously discussed) and record noises. – 15 minutes

Explaining

Then they come back and decide to find some allies and then turn to people in the city to lobby for their cause of improving the city for their needs. These animals know that people don't think too high of their intelligence so they decide to surprise them by collecting factual data about their findings. Students work in the same teams and they collect scientific evidence about how these species hear, what noises they perceive and how, what ecologic needs they have. While doing so, they also collect questions about sounds (Physics) and challenge their hypothesis. The animals have a chance: they can consult a physicist who provides them resources. – 35 minutes
Groups plot happy/sad noise sources on the shared big map and then see and discuss which groups may be their allies in specific cases. – 15 minutes

Elaborating

Then the animal teams design their dream cities. They can decide how to consider people's needs and why. Meanwhile they discover solutions for noise protection. For example: protective walls, changing road surfaces, planting trees or shrubs, roundabouts instead of traffic lights, rationalising traffic, etc. They present their city designs on the shared map for the other groups. – 40 minutes
The teams are challenged to discuss how the city should be transformed according to their needs and to get to a consensus that they can present for the city's human leaders. – 20 minutes

Evaluating

The teams together draft a city design and discuss main challenges in the project. – 20 minutes
Finally, students reflect on how the diversity of points of view may create challenges in city design. – 10 minutes

Suggestion for further reading and discussion

Desmond Morris (1990).The Animal Contract: Sharing the Planet. New York: Warner Books

In the Middle Ages, animals were even cited to city courts to testify. How would that go in the case of the role game above?

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Version 3

Sounds in the city: the diversity challenge

Role game version 2

Basically the same as in role game version 1, but with the difference that individual role cards are issued and these roles represent a real diversity: city pets, city farm animals, insects, bird species, citizens of different age groups (from infant to aging people) and teams are formed based on the part of the city they live. In the Exploring phase, they collect information individually and share first with their own team, then with the whole class. In the Elaborating phase, the challenge is to design the city part, then the teams see how these designs fit together, discuss whether this is operational as a whole city. In the reflection part they reflect on the results and the process from their role's point first and then from their personal point of how teamwork, plenary parts and individual contributions influenced the learning process.

Version 4

Smells in the city

This version is organised as any of the sounds one, but students are exposed to smelling experience as an introduction, then they make smell maps and collect information about smells, air quality, air pollution and as an elaboration challenge they deign an area with attention to smells.

Note: In many curricula though, smelling is less elaborate than vision, also the Chemistry connected to smells is more above the secondary school science than the Physics content in the case of sounds.

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Resources

Delight-distress map visual example: https://www.youtube.com/watch?v=0TiTkJGfBTs
Some resources on birds' singing patterns (in Hungarian):
http://tbuvar.hu/fooldal/2016pdf/TB_2016_05_OK_digitalis_oldalankent.pdf
http://centauriweb.hu/madarakrol/madarakrol-mindenkinek/evolucio-hasado-rigo/
http://epa.oszk.hu/02900/02930/00042/pdf/EPA02930_elet_es_tudomany_2013_42.pdf
Strategic noise maps and noise reduction plans in the city of Győr:
http://innovacio.gyor.hu/data/files/kozgyulesek/1_mell_gyr_zajtrkp.pdf
Noise map of Győr: http://innovacio.gyor.hu/cikk/strategiai_zajterkep.html
The freedom of sound John Cage behind the iron curtain.
http://www.ludwigmuseum.hu/site.php?inc=kiallitas&kiallitasId=805&menuId=44
John Cage 4'33": https://www.youtube.com/watch?v=zY7UK-6aaNA

Sample graphs

Graphs for advanced groups, differentiated group-work (4 groups with different parts of the figure):

from Slabbekoorn, H., Boer-Visser, A. (2006). Cities Change the Songs of Birds. Current Biology, Volume 16, Issue 23, 5 December 2006, pp. 2326-2331, retrieved from https://doi.org/10.1016/j.cub.2006.10.008 (2020.01.03)

Figure 1. Great Tit Song Variation in Urban and Forest Sites

(A and B) Competition for acoustic city space:

- great tit song embedded in urban noise and recorded in a territory right under the Eiffel Tower in Paris, France, and
- a recording from a territory next to Buckingham Palace, London, England.

These two sonograms, (A) and (B), are noisy recordings and also depict all sounds on the recordings, in contrast to (C) to (L), which are high-quality recordings that have in addition been cleaned of background noise and excessive reverberations to optimally depict great tit song-type features.

(C and D) Odd urban song types:

- (C) a single-note song type (four repeated phrases) from London, and
- (D) a 16-note song type (one phrase) from Rotterdam, the Netherlands.

(E–H) Divergence between urban and forest song types:

- (E) typical two-note song type (four repeated phrases) from Brussels, and
- (F) a two-note song type (two repeated phrases) from Rivièra, Belgium;

- (G) typical three-note song type (two repeated phrases) from Prague, and
- (H) a three-note song type (two repeated phrases) from Kolin Forest, Czech Republic.

These examples illustrate possible differences (red arrows) in the minimum frequency (thin yellow line) and the duration of the first note of the phrase (marked with a thick, short, yellow line underneath). Urban birds sing at a higher pitch, in a hurried fashion.

(I–L) Acoustic similarity between shared song types within city-forest pairs:

- A two-note song type (two phrases) from London, and
- (J) a very similar one from Thetford Forest;
- (K) another two-note song type (two phrases) from Paris, and
- (L) a highly similar one from Fontainebleau.

Pair-wise comparisons revealed no significant habitat-dependent differences (blue arrows) in minimum frequency (thin yellow line), the duration of the first note of the phrase (marked with a thick short yellow line underneath), or any of the other spectral and temporal measurements. The same song types are sung in different habitats at the same pitch and at the same speed.

Note:

Groups have similar tasks, but groups 2 and 4 get somewhat simpler challenges than the others.

All sound files and graphs are downloadable from the paper at:
https://www.sciencedirect.com/science/article/pii/S0960982206023086#fig1

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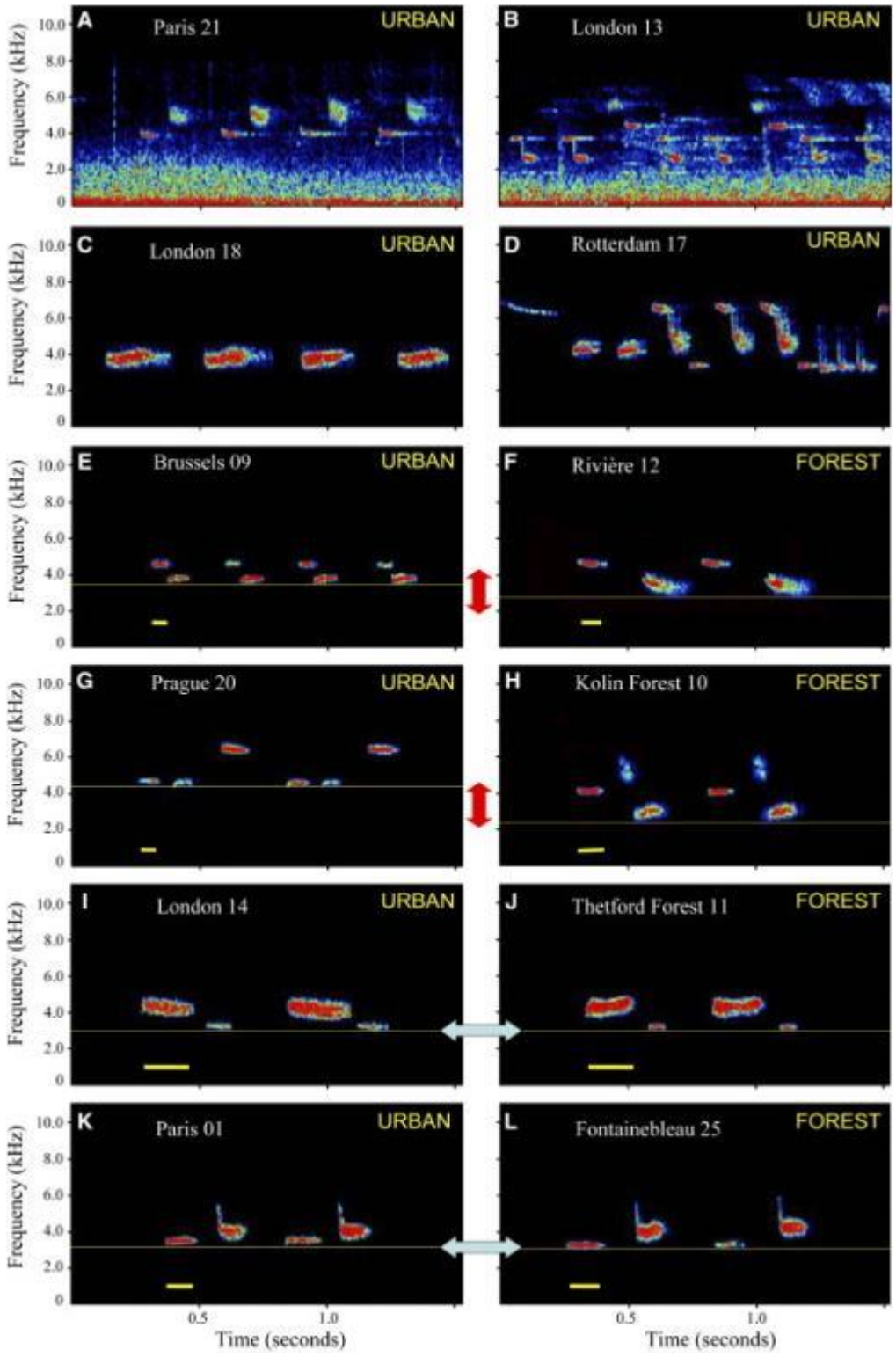

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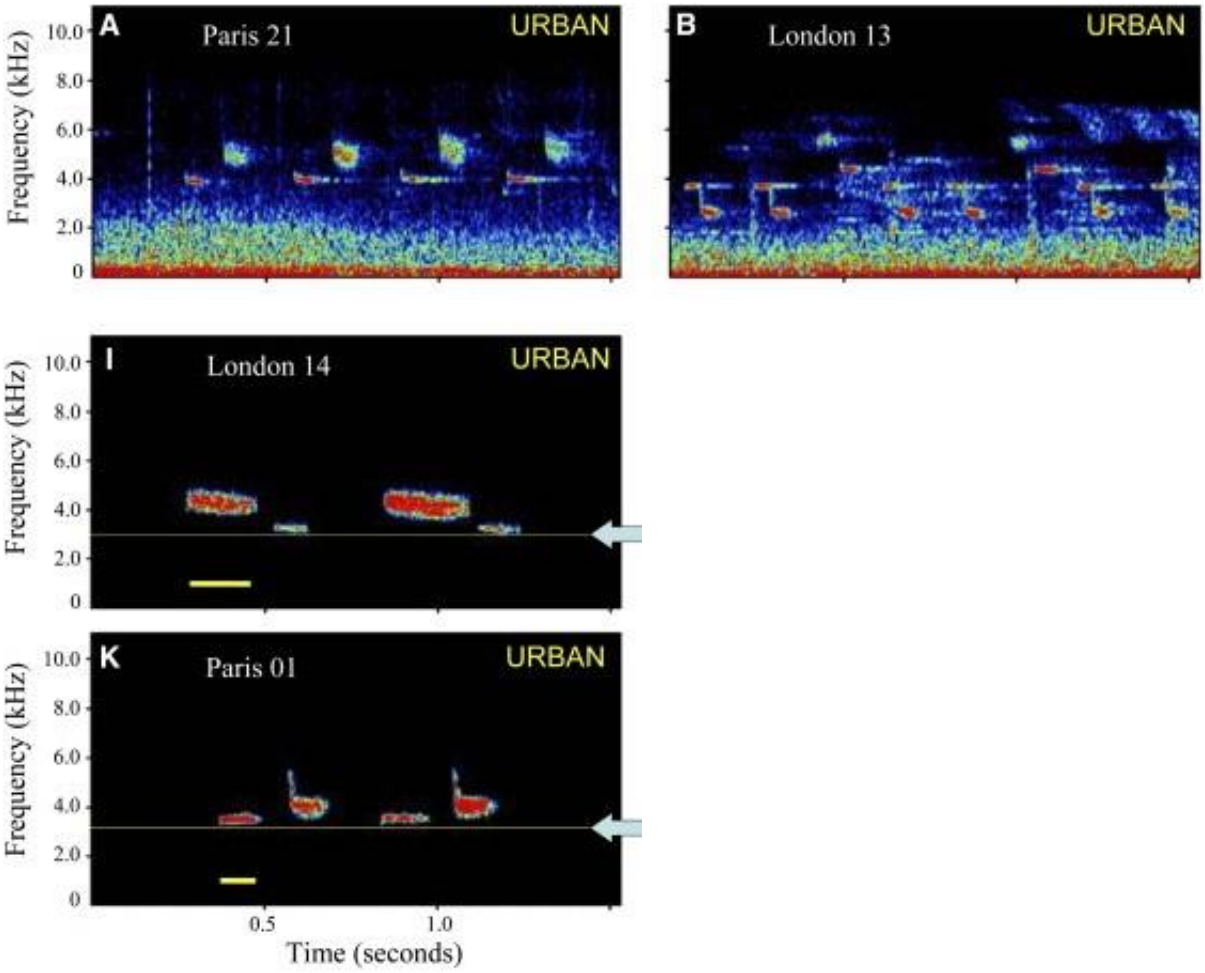
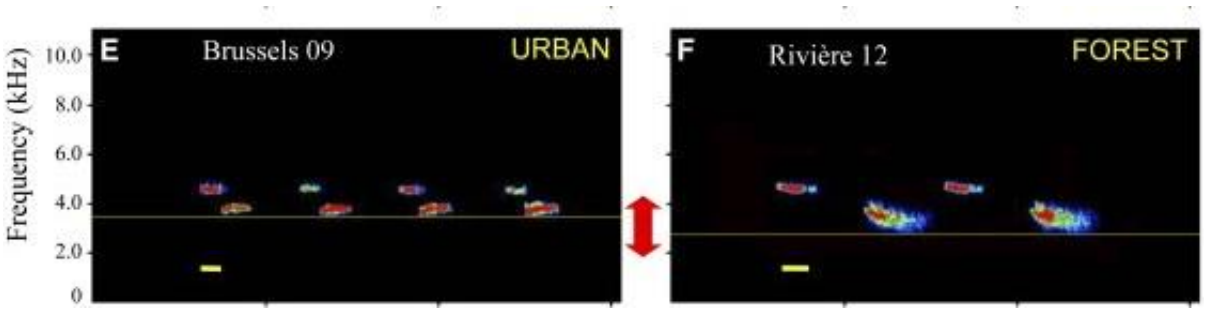
Group 1



Group 2



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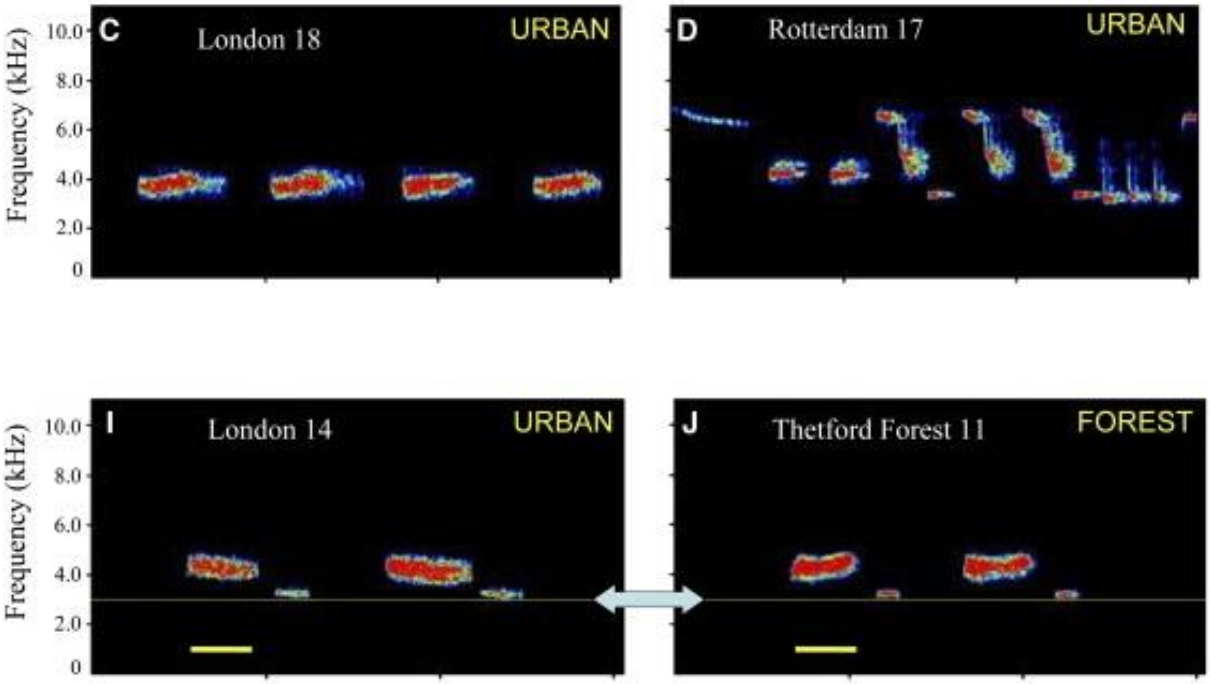
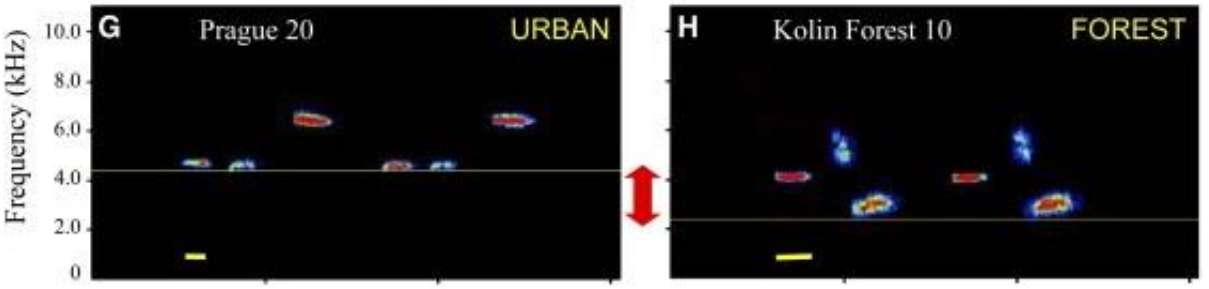
Group 3



Group 4



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Graphs for advanced group, same graphs for all groups:

from Slabbekoorn, H., Boer-Visser, A. (2006). Cities Change the Songs of Birds. Current Biology, Volume 16, Issue 23, 5 December 2006, pp. 2326-2331, retrieved from https://doi.org/10.1016/j.cub.2006.10.008 (2020.01.03)

Figure 2. Great Tit Song Differences between Urban and Forest Sites

(A) Population means of all ten city-forest pairs show a consistent spectral shift in the minimum frequency (Fmin): Every urban site has a higher minimum compared to its forest companion site.

(B) The minimum frequency varies with note number, and the habitat-dependent spectral divergence remains distinct irrespective of number of notes (more than 85% of the total of 613 song types consist of two, three, or four notes). Squares represent song types from cities, and triangles represent song types from forest. Error bars represent means ± standard error.

(C) The minimum frequency correlates between sites of a pair without a strong, larger-scale geographic pattern of isolation by distance. City-forest pairs are labeled in the graph by the city name. We delineated the line of equal values for city-forest pairs in the top-left corner.

(D) Population means of all ten city-forest pairs also show consistent divergence in the duration (DUR) of the first note of the song: Every urban site has a shorter note length compared to its forest companion site.

(E) The duration of the first note varies with note number, but the habitat-dependent temporal divergence remains distinct, especially for the note numbers with substantial sample sizes. Squares represent song types from cities, and triangles represent song types from forest. Error bars represent means ± standard error.

(F) The duration of the first note does not correlate between sites of a pair, nor is there a larger-scale geographic structure. City-forest pairs are labeled again by the city name. We delineated the line of equal values for city-forest pairs in the bottom-right corner.

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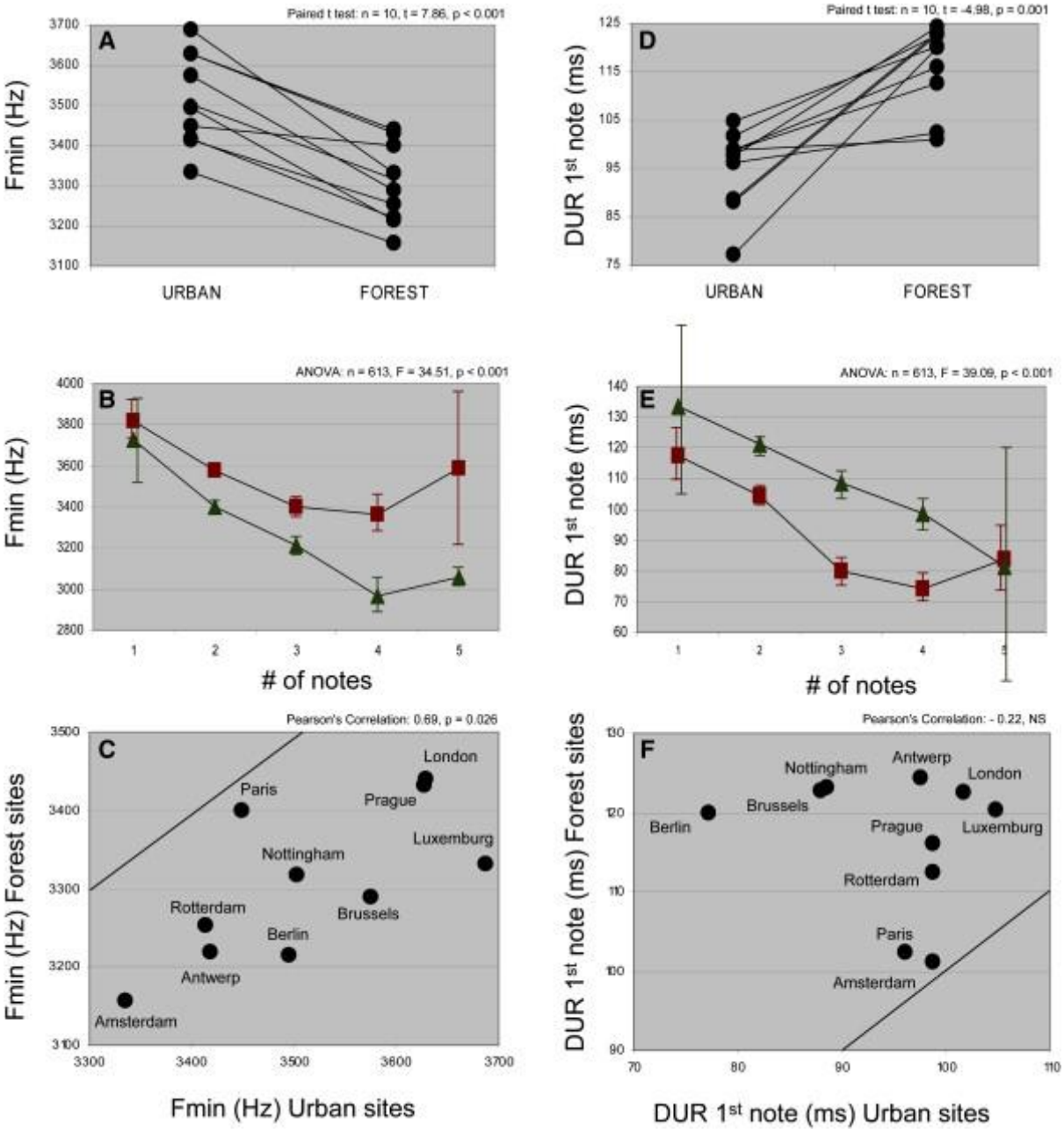

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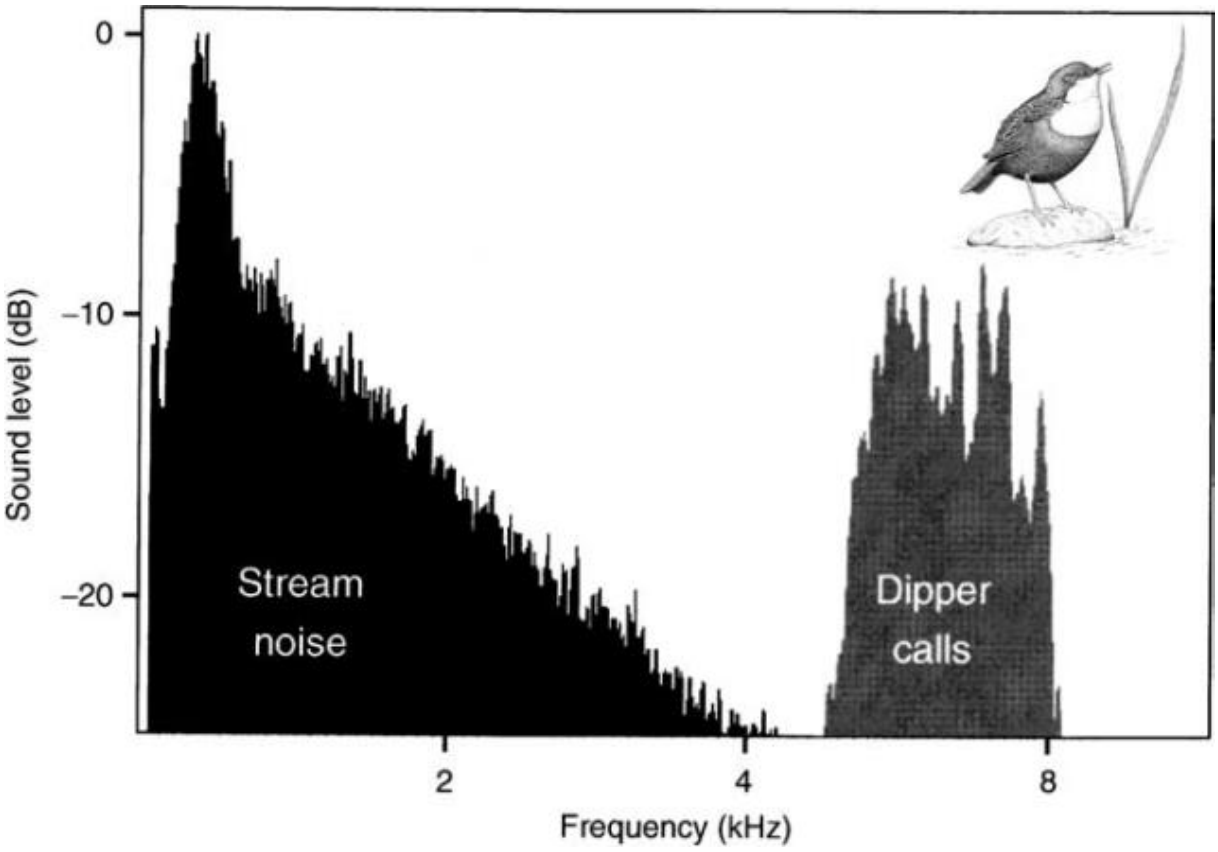
Graph for beginners

Figure 1. Dippers close to noisy streams sing at a higher frequency than the background noise so their songs can be heard (from Brumm and Slabbekoorn, 2005)

from https://ecologicablog.wordpress.com/2015/02/19/urbanisation-is-changing-the-way-birds-sing/

Reference:

Brumm, H. (2004). The impact of environmental noise on song amplitude in a territorial bird. Journal of Animal Ecology, 73 (3), 434-440 DOI: 10.1111/j.0021-8790.2004.00814.x



Note: Other, more scientific figures and graphs from the referred paper can also be used and are downloadable from the website in a Power Point format with proper reference: https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/j.0021-8790.2004.00814.x

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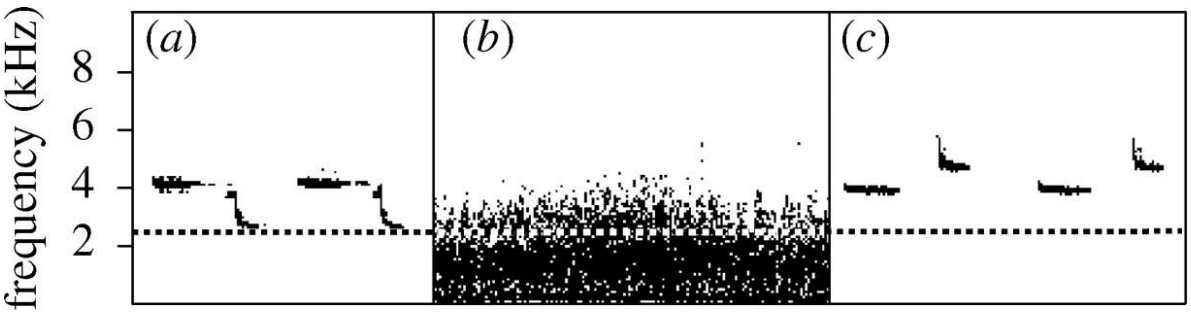
Figure 2. Sonograms of rural (a) and urban (c) great tit song compared to the background noise of a city (b) (from Mockford and Marshall, 2009).

from https://ecologicablog.wordpress.com/2015/02/19/urbanisation-is-changing-the-way-birds-sing/

Reference:

Mockford, E., & Marshall, R. (2009). Effects of urban noise on song and response behaviour in great tits. Proceedings of the Royal Society B: Biological Sciences, 276 (1669), 2979-2985
DOI: 10.1098/rspb.2009.0586



Sonograms of recordings taken in Cambridge. (a) Great tit at rural site. (b) The background noise at the urban site during rush hour from exactly the same location as where (c) was recorded. (c) Great tit song at urban site at a quiet time of day. The dashed line represents the minimum frequency of the rural song. The background noise below 2 kHz has been removed from the sonograms to allow for clarity.

You can clearly see that the urban song is a higher frequency than rural song and above the frequency of the city noise.

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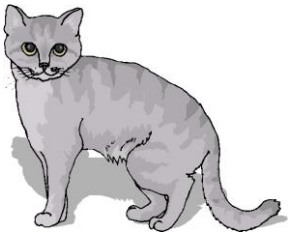
Sample role cards for alternative version 3

	You are a cat. You live with a family in a house in the greenbelt, however there is a main road not far from your house. The family is worried to let you out too much in the garden because of possible accidents due to heavy traffic.
	You are a blackbird living in the park near the central bus station. You are young and you would like to establish a family this spring.
	You are a cricket living in the suburbs in a garden. You like to indicate your home to the others as well as you would like to find a partner for yourself.
	You are a dog living with an elderly lady in the inner city. The lady takes you out regularly, for walking, to the dog beauty salon, to the pet and sometimes even to a restaurant.
	You are a male frog living near the pond in a nice park by the city center. You are motivated to attract as many ladies this spring as possible with your beautiful voice.
	You are a sheep and a farm animal living next to the city. You grew up in this farm and have some ideas how to improve the place.

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	You are a baby living in an apartmant in the inner city. You are really young yet you could share some ideas for improvement.
	You are a working mother. You work in the city center but live in the greenbelt area. There are some noise-related topics that disturb you.
	You are homeless and spend most of your days by the railway station or near a shopping center. Quite often you have no choice but sleep in the streets. Share some of your observations about city noises.
	You live in this city but spend little time at home as you travel a lot because of your work. You don't like when people criticize airports: you need the airport and you are happy that you can reach it quickly from your home.
	You are an elderly woman wearing hearing aids. You live with your pet and often invite friends or family to your garden to enjoy some fresh air and the sight of your beautiful flowers.
	You are a middle-aged person commuting to work from a village near the city. You have been duing this for many years now so you can tell which noises are typical for this city that you would not hear in the countryside – and vice versa.

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Table of points:

Activity	Individual point	Team point	Individual extra	Team extra
Noise recording	1 for each noise recorded	1 after each 5 noise recorded		
Noise maps	Same points for everyone in the small group or the overall points are divided by the group members based on their contribution to the results in a way that the sum of individual points equals the team points.	Clear work: 1 Punctual identification of sources on the map: 4 Presentation:3 Reflection on others' work: (Overall: 10)	Presenting the team's work: 5	If all ready on time: 2x If +10% ready on time: 1x Otherwise: 0
Posing questions based on presentations	1 per sensible questions jotted during presentations	Respect for others: 5		
Clustering questions	Same points for everyone in the small group or the overall points are divided by the group members based on their contribution to the results in a way that the sum of individual points equals the team points.	Participation in the discussion: 2 Clear categories: 1 Proper grouping: 2 (Overall: 5)	Presenting the team's work: 5	If all ready on time: 2x If +10% ready on time: 1x Otherwise: 0
Jigsaw classroom – reading task	If all ready on time: 5 If +10% ready on time: 3 Otherwise: 0	Sum of individual points.	Taking notes: 5	If the sum of individual points exceeds 80% of the total achievable: 2x
Reflecting on changes in birds' singing patterns and noises in the	Same points for everyone in the small group or the overall points are divided by the group members based on their contribution to the results in a way	Using scientific evidence: 1 Referring to data: 1 Reading graphs: 3 Referring to scientific phenomenon	Presenting the team's work: 5	If all are ready on time: 2x If >75% ready on time: 1x

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Activity	Individual point	Team point	Individual extra	Team extra
cities	that the sum of individual points equals the team points.	or law: 1 Using a law to explain a phenomenon: 1 Causality: 1 Clear explanation: 1 Respectful work: 1 (Overall: 10)		Otherwise: 0
Designing noise protection in a city area	Same points for everyone in the small group or the overall points are divided by the group members based on their contribution to the results in a way that the sum of individual points equals the team points.	Using scientific evidence:2 Referring to law: 2 Causality: 2 Legibility: 1 Explanation: 2 Taking initiative: 1 Respectful communication: 1 Empathy for inhabitants of the area: 2 Presentation: 2 (Overall: 15)	Presenting the team's work: 5	If all ready on time: 2x If +10% ready on time: 1x Otherwise: 0
Noise: creative project	Same points for everyone in the small group or the overall points are divided by the group members based on their contribution to the results in a way that the sum of individual points equals the team points.	From 1 to 10, based on other teams' votes' average.		If all ready on time: 2x If +10% ready on time: 1x Otherwise: 0